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CAN AND MUST THE OFFICIAL SPECIFICATIONS FOR THE CHROMIUM CONTENT IN WASTE WATER BE MAINTAINED?

H. Herfeld [1]

(From the Research and Development Department of the West German Tannery School, Reutlingen)

The official specifications which we will have to expect for waste water in the future are going in two directions:

1. Levying of a waste water tax for the removal and purification of waste water. This will be directed toward the amount and load of waste water, i. e., to the contents. At present there is still discussion about the most practical formula for calculation. I shall not go into this here.

2. Requirements which each industrial waste water must meet, with respect to its composition, before it may be introduced at all into public sewage treatment plants. According to the "Suggestions for the Introduction of Waste Water from Commercial and Industrial Plants into a Public Sewage System", which the Husmann committee has worked out, tannery waste water will have to meet essentially the following requirements:

a. Good mixing of the different waste waters, so as not to cause any strong pH shifts in the public treatment plants.
b. Temperature up to 35°C.
c. pH value 6.5 - 9.5.
d. Settleable materials which cannot be degraded biologically

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(1) Presented at the 26th Annual Meeting of the VGCT in Constance am Bodensee on 25 May 1974.

not over 1.0 mg/l; otherwise, no limits.

e. Sulfides oxidized or separated in insoluble form; in certain cases the sludge can be introduced into drains.

f. Oils and fats extractable with petroleum ether, not over 100 mg/l if saponifiable; otherwise not over 20 mg/l.

g. Total content of chromium compounds, dissolved and undissolved, not more than 4 mg Cr/liter; of this, not more than 0.5 mg Cr/liter as chromate.

Meeting most of the requirements will incur certain costs, but is technically possible. The requirement of holding part of the sludge in the tannery is often set up and is undesirable because its removal can offer additional difficulties. It also appears unreasonable to me because the treatment plants must remove the slime precipitating there. Also, the amount of sludge is already taken into account in the formulas now being discussed for calculation of the waste water taxes from the waste water load. Meeting of the requirement for a largely chromium-free waste water, however, presents the greatest problems for most leather factories at present. This raises the question of whether the requirement of the Husmann committee in this respect can be maintained at all and, on the other hand, whether the requirement at this level is justified. We are intensely concerned with both questions.

I. Can the Official Requirement Be Maintained?

It is well known that in chrome tanning, the chromium salts used are not taken up by the hide without leaving any residue, so that certain residual amounts get into the waste water. We have performed extensive studies to answer the question of how these residual amounts can be reduced. Here, I shall not go into the technical details of these studies, which are widely published in brief form. We shall state only the following, in summary:

1. By the classical chromium tanning with long residual baths of 100-120% and use of 2.5% chromium oxide, some 2/3 of the amount of chromium used is taken up by the hide. One third, i. e., 8.33 kg of Cr_2O_3, or about 5.6 kg chromium per ton, remains in the bath. The residual liquor from the chrome tanning, of course, is diluted with the waste water from the other stages of manufacture. While in the 1950's, for instance, a water consumption of 150 to 220 m^3/ton of crude skin processed was still considered normal for chrome upper leather, it has become possible in the last decade to reduce this volume decisively, so that today the value might vary between about 40 and, at most, 100 m^3/ton [1]. If we figure on 100 m^3 water in which 5.6 kg chromium remains dissolved, this gives a chromium content of 56 mg Cr/l in the mixed waste water, and twice that chromium content, 112 mg Cr/liter, with 50 m^3 waste water/ton. These, then, are values which are far from the requirements of the Husmann committee.

2. By working with short soaks with residual soaking volumes of 40-45% and by varying the working conditions and using chemicals which improve the bath consumption, one can improve the bath consumption to 75-80%. If the yield is 80%, then 5 kg Cr_2O_3 = 3.34 kg Cr/ton of raw material would remain in the chrome tanning bath. Then, with 100 m^3 waste water/ton, the chromium content would be 33 mg Cr/liter. With 50 ton waste water, there would be 67 mg Cr/l in the mixed waste water. According to our investigations, one can perhaps increase the utilization up to 90% by a combination of the "dry chrome tanning" reported by Schorlemmer [2] as early as 1922 with a brief formic acid pickling. This would reduce the chromium content in the mixed waste water further to 17 or 33 mg Cr/l, respectively. But none of these values will yet meet the requirements of the Husmann committee.

3. It is possible, however, to attain 100% chromium utilization in the following ways:

a. The chromium residual soaks are used as pickling soaks for the subsequent lot. This way is immediately accessible. It assumes the maintenance of certain concentration conditions in the pickling and chrome tanning.
b. The chromium is precipitated as the hydroxide, left to settle, dissolved again with acid after decanting off the supernatant liquid, and the resulting solution is used for pickling after addition of pickling acid and perhaps small amounts of sodium chloride.
c. The chromium of the residual soak is precipitated as the hydroxide. The slime is largely freed from liquid in filter presses. After the filter cake is redissolved with acid, the solution obtained can either be mixed with pickling acid, sodium chloride and water, and used for pickling the next lot, or it can be added to the tanning bath for the next lot.

All three methods lead to a saving of chrome dying materials. In the first methods, residual chromium liquors disappear completely. There are residual liquors in the other two methods, to be sure, but these contain only very small amounts of chromium, no more than 50 to 70 mg Cr/liter. With dilution in the proportion of at least 1:100 by the other washing and waste water, this would correspond to a content of chromium compounds of less than 1 mg Cr/liter, so that the official specifications would be met by all three methods. The leathers are of good quality. The use of the residual amount of chromium in the pickling bath even has a good effect, especially on the scar characteristics. Both the first two methods could be carried out without significant analytical checking. This would be particularly important to us in order

to keep the process simple even for small and moderate-sized operations.

4. By the processes listed under 3, no residual liquors, or almost chromium-free liquors, occur. This solves the problem from the view of chrome tanning proper. Unfortunately, it is not entirely solved. The chromium taken up by the hide is not bound entirely. Part of it is pressed out in dewatering, and some is washed out of the skin again in the following washing, neutralization, and other processes of wet dressing. In addition, many post-tanning agents also displace certain proportions of the chromium out of its bonds with the skin material. We have also determined these amounts of chromium quantitatively, and have established that an average of 8% chromium is removed from the leather in dewatering, and a total of 2-7% of the chromium used is washed out of the leather again in the following processes of neutralization, post-tanning and washing. With use of 25 kg Cr_2O_3/ton of raw material, this means about 2.5 to 3.75, or, on the average, 3 kg of Cr_2O_3 = 2.0 kg Cr/ton, or 20 mg Cr/liter with a water consumption of 100 m^3/ton, or 40 mg Cr/liter with a water consumption of 50 m^3/ton, in the mixed waste water. In practice, the values are even higher, as certain losses from emptying vessels and dropping the wet leather on the table or palette must be added. They are even higher if only pre-tanned material (wet blue or crust ware) is processed, because then the dilution factor with other plant waste waters is less. Thus the total values exceed the maximum limits established by the Husmann committee. One must consider also the waste water from dewatering and all stages of wet finishing, and the chromium present in it, in order to be able to meet the Husmann requirements. That, of course, can be done in theory, but it would be linked with a considerable financial cost, both for construction so as to be able to collect all these thin

residual liquors and treat them separately, as well as from the labor cost of the treatment itself. That would very seriously use up the capability of the industry, and before one seriously discusses such measures, there necessarily arises the question of whether the present requirement of the Husmann committee with respect to limitation of the content of chromium compounds in waste waters is justified at all. With that, we come to the second part of this report.

II. Is the Official Specification Correct and Necessary?

Where can the chromium compounds in the waste water cause damage?

1. The waste water arrives at the treatment plant. Here, the biological treatment by the activated sludge process or the subsequent digestion of the activated sludge can be disturbed. To clarify this question, Konigfeld [3] has carried out detailed studies, and can show that in the activated sludge process, the chromium concentration can be increased to at least 500 mg Cr/liter of waste water without any effect on the biology. The same is true for the addition of insoluble chrome leather grinding dust, in which case amounts of up to at least 2,500 mg grinding dust per liter of waste water had no unfavorable effect. These values, therefore, are considerably higher that can be found in a tannery waste water, according to the previous calculations, even in the most unfavorable case. In sludge digestion, up to at least 3,200 mg Cr/liter sludge = 10% chromium, referred to the dry sludge, no disturbances in the bacteriology occurred. If one considers that the chromium content in pure tannery sludges normally varies between 1.2 and 1.7% of the dry substance, according to our own investigations and to the result of inquiries, these values are also considerably lower than the

potential limiting concentration. It must be considered that at most treatment plants, the tannery waste water is treated along with household wastes or other industrial waste waters, so that the chromium content must be significantly lower, depending on the mixing ratio.

In all cases, of course, it was assumed that the chromium compounds are added to the activated sludge process or to sludge digestion in insoluble form. This is quite understandable. The compounds of trivalent chromium have no "toxic effect" at all in the true sense of the word on the microorganisms in biological waste water and sludge treatment, but they are able to tan the enzymes, which are also proteins, and so to make them inactive. But they cannot tan if they are insoluble, so that the results of Königfeld are entirely understandable. Because, according to the instructions of the Husmann committee, the pH value of the mixed waste water taken off must be between 6.5 and 9.5, and the optimum for chromium precipitation is also in this range, then the greatest part of the chromium compounds in these mixed waste waters is then automatically present in the insoluble form, so that no difficulties can appear in biological waste water and sludge treatment. Gauglhofer and Weber [4], to be sure, found a somewhat lower limiting value in their studies than did Königfeld, if they used strongly masked chromium liquors, which do not precipitate as easily in the alkaline region. But they used extremely high amounts of Neutrigan (in one case, 6.4 kg per 1 kg Cr_2O_3, and actually 133 kg Neutrigan in another case). These amounts are not used in practice, by a wide margin; otherwise, the tanning ability would be completely prevented. In his sludge experiments, Königfeld used a formate-masked chromium liquor, with 0.658 kg sodium formate per 1 kg Cr_2O_3, corresponding to the practical common degree of masking. With this, he even got an increase of the limiting value.

From the viewpoint of biological waste water treatment, accordingly, there is no reason for holding to the limit which the Husmann committee established for chromium compounds in waste water. It must be emphasized that all plants should unconditionally maintain the Husmann committee requirement for limiting the pH value, even if they perhaps process only pretanned material and therefore have only acidic waste water, because this is of decisive importance with respect to the harmlessness of the amounts of chromium taken away in the undissolved state.

2. The second question is whether the sludge appearing in the treatment plants, which contains the chromium compounds primarily in the insoluble form, can be used without damage as an agricultural fertilizer. Here there have been several investigations concerned with the specific question of the effect of chromium compounds on the growth and the yield of plants; but they report no uniform picture. The Documentation Office for Soil Science, Soil Maintenance and Plant Nutrition, Braunschweig-Volkerode, with which we corresponded on this matter, justifiably defended the view that each element produces specific effects in plants in deficiency or excess, so that, with contradictory results, it is quite probable that other factors are acting, which can easily falsify the results. For chromium, in this sense, the pH value and lime content of the soil, phosphate fertilization, and the presence of other components in industrial sludges could play special parts.

In order to clarify further the question of the specific chromium effect, Prof. Kick, Director of the Agricultural Chemistry Institute of the University, Bonn, has at our suggestion carried out very extensive studies on this question. From his summary report, we can take the following results:

a. Fundamentally, chromium compounds can be found in all plants and in all soils. There is up to 100 mg Cr/kg of soil in German soil, and in plants, an average of 0.15-0.24 mg, with up to 0.59 mg Cr/kg dry substance in hay. Theoretically, then, we can discuss a harmful effect of chromium-containing sludges in agriculture only if their chromium content exceeds some 100 mg Cr/kg dry material.

b. The effect on plants differs in degree with different plant species. Minor amounts of chromium salts never have a harmful effect and in many cases they even increase the growth and yield. A disturbing effect appeared only at higher additions. In acidic soils with pH values below 5.5, a reduction of yield could be detected in the year of application if the chromium addition was above 500 mg Cr/kg soil, corresponding to 1,500 kg Cr/hectare.

If the soil pH was above 7.0 there was no yield reduction even if the addition of chromium was raised to 1,000 mg Cr/kg soil, equivalent to 3,000 to 3,500 kg Cr/hectare. With meadow grass, as much as 2,000 mg Cr/kg soil = 6,000 kg Cr/hectare could be added before a distinct growth depression could be detected. In general, according to the experiments by Prof. Kick, the limits of damage to plant growth begin to become perceptible at a continuous chromium enrichment by chromium sludge in the soil at some 1,200 - 1,500 mg Cr/kg soil, under the most unfavorable conditions. In this respect, the following viewpoints in particular should be considered:

a. The limiting values presented above were determined by adding the amounts of chromium-containing sludges on the soil all at once. But it is important that in the soil, the chromium is believed to become harmless due to the increasing oil formation from the chromium complex. Thus,

for instance, a total chromium addition of some 3,000 kg/hectare administered directly to mustard gave a reduction in yield, while there was no longer a loss of yield in the following year. Therefore, the longer the chromium application is before planting, the less the effect on growth will be, so that in practice, the limit for damage from chromium-containing sludge which is added in separate portions distributed over many years may be even higher than the numbers above indicate.

b. Here, too, it is important that the damage is particularly low if the soil is not acidic, so that the chromium is in an insoluble form and remains in the insoluble form. The total content of heavy metals in the soil is not a measure for their uptake by plants; it is, rather, only their solubility [5]. Therefore, Prof. Kick refers to the importance of sufficient liming of the soil; this, independent of the chromium availability, is usually a pressingly necessary measure in our soils.

c. From various sides it has also been suggested [5] that the role of the phosphate content in the soil is also important for the insolubility of the chromium. The insolubility of chromium is increased even more by phosphate-containing fertilizers, so that the effect of the chromium was even less with phosphate-containing fertilizers, than in corresponding rapid tests without basic fertilization with phosphate. A reduction in yield from chromium-containing sludges can, then, be affected favorably by simultaneous phosphate fertilization. Simultaneous fertilization with Thomas phosphate meal is particularly recommended, because this simultaneously increases the phosphate content and the alkalinity in the soil.

Professor Kick has referred to the fact that the limiting value of 3,000 kg Cr/hectare, assuming a content of 1 g Cr/kg dry sludge, would correspond to an amount of 3,000 tons of dry sludge or some 43,000 tons of wet sludge with 7% dry content. At an application rate of 330 m^3 wet sludge every 3 years, one could apply wet sludge with this content level for 430 years before a perceptible damage would be reached, assuming that the pH in the soil was above 7. Pure tannery wastes, to be sure, would show a higher chromium content, but if one considers that the aging factor was not considered in the calculation above and, on the other hand, mixed sludges with considerably lower chromium content always appear in the treatment plants of communities or waste water unions, then these numbers show that there is no practical reason to fear damage from chromium-containing sludge in agriculture. Therefore, from this viewpoint, also, the severe limitation of the Husmann committee cannot be justified.

3. In all cases, small amounts of chromium are taken up by the plants. When we suggested increasing the Husmann value we encountered, on the official side, the argument that there was a possibility that these small amounts of chromium compounds taken up by the plants might under some circumstances reduce the nutritional quality. Therefore they could not agree to raising the Husmann value without knowledge of the nutritional-physiological effects of increased chromium content in foods on man and animals. Prof. Kick also refers to the inclusion of chromium in the food chain. In his investigations, for instance, at a chromium addition of 1,000 mg Cr/kg soil, he has established an increase in the plant chromium content of 1-2 mg/kg dry plant material. But he leaves open the question of the chromium tolerance of the organism. But clear statements can be made about this question. Naturally, the literature on this subject is not completely available. To the extent that we know, or have been able to obtain from friends, the following statements

apply [6]:

Chromium is one of the trace elements which occur everywhere in nature and are just as important for life as the vitamins, for instance. Deficiency of trace elements can very severely reduce the capability of the organism. Feeding of naturally grown crops, in and of itself, introduces such minerals to the bodies of man and animals in sufficient amounts. But the modern technological food processing methods in all cases cause considerable loss of minerals. If this tendency continues, latent mineral deficiency phenomena will appear as frequently in the coming decades as vitamin deficiency. The World Health Organization was, therefore, concerned with the importance of the trace elements in human nutrition, in the structure of an expert committee meeting in Geneva, in April, 1973. The total trace elements were divided into 3 groups:

a. Essential elements - those which have been shown to be very important. An element is designated as essential if its deficiency in the food reproducibly decreases the function and capability of the organism. They are usually components of metalloproteins and metalloenzymes, or activators of enzyme systems. Latent mineral deficiency due to the lack of such essential minerals are much more common than is usually believed.

b. Possibly essential elements.

c. Randomly present trace elements, which are not important for the organism, some of which, like the compounds of mercury, lead, cadmium and arsenic, can have a distinctly toxic effect.

Chromium is in the first group of essential minerals which are definitely required for the well-being of animals and man.

In the case of chromium, the necessity for man has been proved satisfactorily, and is certain. Chromium compounds are, for instance, ascribed a great positive physiological significance for the enzyme balance, as they are believed to exert a stabilizing effect on many enzyme activities through complex salt formation and intramolecular bridge compounds. They are essential, for instance, for the appearance of the action of insulin [7]. All soluble salts of trivalent chromium are effective. There is also particular reference to the outstanding biological value of chromium in beer yeasts.

For chromium and some other metals, it is specifically stated that they are much less toxic than generally assumed. Because some heavy metal salts have toxic effects, as I mentioned above, other trace elements of heavy metals are often prejudged by laymen and suspected by many officials, although this suspicion is entirely unfounded. Thus, the body can tolerate surprisingly high amounts of chromium for a long time without any damage being expected [8]. In no case is chromium to be mentioned in the same breath with the toxic elements listed. There are also elements and their salts which are not fundamentally toxic, but which in large amounts can have a considerable toxic effect, such as the salts of copper, molybdenum, selenium, fluorine and iodine, etc. But this is not the case for chromium.

Sykes [9] has recently published an interesting work concerned with environmental problems from the viewpoint of the leather industry. With particular respect to the chromium compounds in the waste water, he gave the following suggestions:

a. Mertz [7], in an extensive report on the biological activity of chromium, has found that "no reports on toxicity of trivalent chromium administered to the organism orally are known".

b. Investigations of the survival time of organisms which had chromium added to their drinking water showed that no disease effect at all could be demonstrated which could be traced back to the chromium [10].

c. Akatsuka and Faihell [11] fed cats up to 1 g of chromium compounds per day for 3 months without disease symptoms being observed, and also without establishing retention of the chromium in the organism.

d. Cr_2O_3 was used in England as an inert marker for indigestibility studies in animals [12] and the Food and Drug Administration in the USA allowed leather wastes used for hog feeding to contain chromium compounds at up to 270 mg chromium/kg in the mixture.

e. Chromium is of proven importance for the human metabolism. Certain diseases can be related to chromium deficiency [13]. Although not yet confirmed, aging persons particularly need chromium. Fanatics for healthy nutrition have already accepted this as desirable [14].

Any toxicity, of course, depends on the amount of material absorbed; and one often says that there is hardly an element which would not endanger health above a certain concentration, raising health problems. This raises the question of what amounts of chromium compounds humans and animals can take in. There is extensive documentation on this. It was provided by the Hygienic Institute of the Ruhr Region, Gelsenkirchen, under contract to the Ministry of Food, Agriculture and Forests of the State of North Rhein-Westfalia, and reports the effective concentrations of potentially dangerous materials in water. For chromium compounds taken orally in the water, this maximum effective concentration is 0.5 to 5 g/kg body weight

for chromium sulfate, and as much as 5-15 g/kg body weight for insoluble chromium oxide. (The same would certainly apply also for uptake in the food). This does not refer to intake through inhalation or injection. For a man of 70 kg body weight this would be an absolute quantity of 35 - 350 g of chromium sulfate or 350-1050 grams of chromium oxide. If Prof. Kick, in his experiments, established increases in the chromium content of plants by 1-2 mg/kg dry plant material, this clearly demonstrates the complete harmlessness of such increases.

The compatibility limits of fish for chromium compounds, reported in the same documentation, are also of interest in this respect. For trivalent chromium salts this limit is generally up to 42 mg, and up to 200 mg/l for chromium sulfate. This, then, is considerably higher than the content of soluble chromium compounds in a tannery waste water, if the pH value would be adjusted to pH 6.5 - 9.5, according to the requirements of the Husmann committee, so that the chromium would largely be precipitated and not get into the drainage channels.

From all these results and documents, one must answer the second great question of the need for limiting the chromium content in waste water, as planned by the recommendations of the Husmann committee, with a clear No. Even though not all the literature on this question is available, all the literature sources listed show clearly that chromium compounds are harmless in the nutritional-physiological view, and that on the other hand they are actually necessary as compounds of an essential element. In one article it is expressly stated that the essentiality of chromium, as for a series of other elements, is no longer just discussed, but is sufficiently proven [6]. The author then continues: "If the World Health authorities recognize that, why not the national health authorities also? The prohibition of enrichment in physiologically reasonable amounts has in fact lost its importance". For the German

authorities, there can be only 2 conclusions. Either one accepts the statements which have been made, and then our conclusion that the establishment of a limit for chromium compounds in tannery waste waters was made unnecessarily severe is correct; or one doubts the extensive determinations which have been made on this question, in which case one must quickly perform appropriate studies in Germany before forcing an industry to use costly measures to reduce the content of chromium compounds in waste water, without there being any need for it from the viewpoint of environmental protection. To our knowledge, an extensive research problem on the total problem of environmental protection is being planned and supported in the Federal Ministry for Research and Technology. In this framework, appropriate studies could be undertaken on the nutritional physiological significance of chromium in food, if it were considered necessary. The leather industry cannot bear the burden of proof. Rather, it lies with the deciding authorities, given the multitude of internatinal studies which already argue against the harmfulness of chromium in foods. Milan1 [15], in an article, "Waste Water Elimination – Pragmatic or Strategic?" has recently said of this: In such a complex starting situation, if one wishes to issue very stringent provisions, then the most secure bases possible are essential. This means that before any decision, ecologically based data on the harmful effect of certain materials are necessary. And where a reduction of the load is desired, but is not conclusively based in ecology, then when limits are established it is necessary to consider the practical possibilities of meeting them".

We hope that this has given a survey of the status of the situation. In conclusion, we wish to expressly emphasize that we by no means intend to fight reasonable specifications for waste water cleaning. Everyone knows today how important the problems of environmental protection are for humanity, so

that the whole problem is of particular importance in highly industrialized countries like the German Federal Republic. No leather producer will resist a reasonable reduction of the chromium content in his waste waters. Obviously, such measures involve additional costs which the industry, as the cause, must accept. But on the other hand, the resulting costs must remain within economically bearable bounds for the capability of the industry, and the requirements for cleaning the waste waters should be held in the limits given by proved limits of damage. Everything beyond that is an unnecessary and unreasonable requirement. We believe that all the results argue for a reasonable compromise which, in our opinion, should lie at a maximum limit of some 50-60 mg Cr/liter of total waste water.

We would not wish to end these discussions without referring to the fact that compounds of trivalent and hexavalent chromium are repeatedly treated alike. The severe toxic effect of compounds of hexavalent chromium is unargued; but the tanning effect is linked with the triple valence of the chromium, so that only trivalenc chromium compounds can get into tannery waste waters. According to what we have presented, these are not harmful even in larger amounts. All the provisions of this lecture have referred only to compounds of trivalent chromium. If that were finally recognized, many unnecessary discussions could be avoided.

In this sense, I wish to counter here any possible objections from industrial hygienists, among whom dangers to health from chromium compounds come up for discussion again and again at regular intervals (damage to the external skin and nasal mucous membrane, gastrointestinal sickness, liver injury). If one follows up the situations, here, too, trivalent and hexavalent chromium are usually not exactly separated. Statements in the

expert literature which, to the extent that clear statements are made, refer to the effect of hexavalent chromium compounds (chromic acid, chromate) in chromate plants, galvanizing plants, etc., are thoughtlessly transferred to trivalent chromium compounts. Most authors refer to a publication by Buess [16] which reports the occurrence of chromate injuries in chromium recovery from dye residues during the last war. This, then, distinctly deals with hexavalent chromium compounds. It could be that cases of idiosyncrasy against trivalent chromium compounds occasionally occur, but that is very rare. We would rather say that strawberries are dangerous to health because people occasionally develop rashes after eating them. The fact that there is a Maximum Workplace Concentration only for hexavalent, but not for trivalent chromium compounds also proves that the trivalent chromium compounds are not harmful. Finally, let us refer to Pamphlet 7 of the Federal Ministry for Labor and Social Order, "Diseases From Chromium and its Compounds", in which it is said on page 63: "There is scarcely any danger to health . . . from compounds of trivalent chromium such as chrome alum, chromium(III) chloride and sulfate, which are used in tanneries, for instance, as well as from chromium(III) oxide. On the other hand, compounds of hexavalent chromium are a source of danger."

There is nothing to add to that statement.

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